FOOD PLOTS IN RELATION TO FOOD AVAILABILITY FOR BOBWHITE QUAIL

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CHAPTER I

INTRODUCTION

With hunting pressure increasing, today's wildlife manager must search continually for ways to increase production and utilization of wildlife. Planting agricultural food plots, discing and burning to encourage growth of annual plants, and thinning tree canopies are commonly done to improve habitat and increase production of wildlife populations. Habitat treatments have been utilized widely for bobwhite quail, Colinus virginianus, (Davison 1949, Rosene 1969, Stoddard 1950) and other animals (Larson 1967). Planting agricultural food plots is the management technique most commonly practiced for quail on state game management areas and is often recommended, through various educational media, as a management practice for private land owners who wish to improve game populations on their land.

Agricultural food species such as wheat (see Appendix A for list of common and scientific names used in text), sorghum, and soybeans are important in the diet of bobwhite quail (Harshbarger and Buckner 1971, Larimer 1960, Robel 1969) and are commonly planted in food plots. However, agricultural foods may be utilized by quail primarily due to availability and abundance (Baumgartner, et al. 1952) rather than because of superior quality. There is n evidence that seeds from cultivated plants are superior in nutritional quality or palatibility to seeds from native wild plants.

Planting food plots, discing, burning, and thinning are often done in an attempt to supplement the natural food supply, assuming that the natural food supply is inadequate to support quail populations of some desired density. Research to test the validity of such an assumption has rarely, if ever, been performed before management techniques were applied. Other factors besides food can restrict the size of a quail population.

In order to test the hypothesis that food is a limiting factor, we need to know the amount and quality of food available to quail. If adequate food is available to meet nutritional needs of quail, then other limiting factors may be more important. Burger and Linduska (1967) found that winter cover and nesting cover, not food, were limiting quail populations on Remington Farm's Experimenta Area. In recent years researchers have questioned the value of food plots (Larson 1967, Murray 1958) and emphasized the need to evaluate this management practice.

Increasing the food base may not be the only justification for applying cultural treatments. Factors such as improving cover conditions for escaping, nesting, dusting, and brooding may be considered. Food plots, burned areas, and disced strips provide areas of light ground litter that allow easy movement for quail, especially chicks. Concentrating birds for harvest may be another important role of food plots.

Knowing the value and effects of frequently used quail management techniques such as planting food plots, discing, and tree thinning is essential to use funds most efficiently. The objectives of this study were to determine: (1) the plant and animal foods available for bobwhite quail in various types of natural and manipulated habitats and (2) seasonal variation in availability of food.

CHAPTER II

METHODS AND MATERIALS

Field Procedures

Bobwhite quail are primarily seed eaters. Animal matter, leafy green vegetation, and fruits are utilized to a lesser extent. Quail feed on the soil surface and in the lower 20 cm of vegetative cover (Rosene 1969). Techniques utilized to obtain samples of foods available to quail from June 1972 through March 1973 include sampling soil for seeds and invertebrates (Ripley and Perkins 1965) and sweep net samples for insects dwelling in vegetation (Hurst 1970). Categories of food include: seeds, nuts, and fruits in the top 12 mm of soil and the lower 20 cm of vegetation; arthropods, gastropods, and other animal matter present in the same soil and vegetation stratum; succulent green herbage in the lower 20 cm of vegetation; and arthropods located between 0 and 38 cm above the ground.

Few studies have been made on the availability of quail foods, perhaps due to problems associated with extremely high variation found among samples and the tedious, time-consuming work. Only two studies have included statistical analyses to determine real differences in production between habitats or seasons (Ripley and Perkins 1965, Robel and Slade 1965).

Robel and Slade (1965) determined availability of onl two species, sunflower and ragweed. Interpretation of their data is difficult because their method of selecting sample plots was not random. Ripley and Perkins (1965) found that approximately 10 samples taken by the methods I used were enough to detect significant differences between two areas if each area was fairly homogeneous. Ten sample from the Canton study area were not adequate for statistical evaluation due to extreme heterogeneity in the habitat types.

Baumgras (1943), Bishop and Spinner (1946), Bookhout (1958), Haugen and Fitch (1955), and Korschgen (1958) attempted to use sample means to compare the food availabl to quail in various habitats and seasons. No statistical testing of the means was performed in these studies to aid interpretation of data. Evaluation of the results without the aid of statistical testing is risky, judging from the wide range of means that were found not statistically different in this study.

Six parameters were investigated: total availability of seeds, availability of seeds important as quail foods, total seed species (species diversity), invertebrates important as quail foods in the soil core samples, invertebrates important as quail food in sweep net samples, and frequency of occurrence of succulent green vegetation.

A standard 38 cm sweep net was used to collect sample of animal matter in vegetation. The hoop of the net was held perpendicular to the soil surface and as close to the top of the ground as possible. Each sweep was approximate 122 cm long. Twenty-five sweeps were made in each samplin unit. Maximum area swept per sample was approximately $11.6m^2$. Sweep net samples were taken from June through December 1972. From December through early spring little or no insect matter was picked up by the sweep net so sampling was discontinued in that period. When a sweep net sample was complete, the insects were emptied into a small plastic bag which was tied, tagged, and labeled with the plot number.

Certain characteristics of vegetation made sweep net sampling very difficult or impossible. Heavy bush hindere efforts to keep the hoop near ground level and maintain a constant sweep. Stands of field sand bur in open or disturbed areas made sampling painful and extremely difficult, especially during early fall when burs were mature but had not fallen. In dense stands the burs would completely cover the inside and much of the outside of the bag and make removal of contents impossible. Sweep net samples were not taken when sampling plots fell in such stands.

The sweep net method of estimating biomass of arthropods has some disadvantages, but it is simple, rapid and requires a minimum of equipment. Pit fall traps were tried in an attempt to obtain a better estimation of ground dwelling arthropods, however, the technique was both time consuming and inconvenient and was discontinued. Hurst (1970) compared sweep net sampling with vacuum sampling using a D-vac machine. He believed that the D-vac gave a better estimate of the biomass of arthropods available to quail than the sweep net. The sweep net oversampled large arthropods that are not available to quail and sampled in an area out of reach of quail. Unfortunately, the D-vac machine could not have been carried with the rest of the sampling gear and would have necessitated a separate sampling procedure.

Samples of the top 12 mm of soil and lower 20 cm of vegetation were taken to determine quantities of seeds, nuts, arthropods, gastropods, and green succulent vegetation available to quail. Some food items in the top 12 mm of soil may not be available, although the loose nature of the soil should allow quail to scratch down at least that far while foraging. A pipe of 7.6 cm inside diameter and 21.6 cm long was used to collect the samples. At each sampling point this sampler was lowered vertically over the vegetation and forced 12 mm deep into the soil. Vegetation protruding above the top of the sampler was cut and discarded. A narrow, flat-blade shovel was forced under the bottom of the sampler to shear off roots or debris that might interfere with removal of the core. The shovel and sampler were then lifted clear of the ground and all soil and debris outside the sampler was brushed away. The core was then dropped in a plastic bag for storage. Eight of these soil-vegetation cores were taken at each plot location as recommended by Ripley and Perkins (1965), and their combined contents treated as one sample. The total area sampled at each plot was 364.7 cm^2. Due to the great diversity encountered within habitats more cores per sample might have been warranted to detect more easily differences between habitats and seasons. Increasing the number of cores taken would greatly increase field work and time required for laboratory analyses.

Succulent green vegetation is often found in quail crops (Table I). Its nutritional function is not clear. Some investigators feel that "greens" may be an important source of vitamin A, particularly during the breeding season (Lehmann 1953, Nestler 1946). No consistent seasonal trend in utilization of green vegetation can be found in quail food habits studies (Table I). Considering the relatively small amounts of green vegetation normally found in quail crops, an intensive effort to determine the available quantity of this food did not seem justified. Therefore, the percentage of the eight soil core subsamples that contained fresh green vegetation was recorded, giving a frequency of occurrence for each plot. Only fresh sprouts of Gramineae and Leguminosae were counted, therefore the values obtained should be a minimum estimate of availabilit of "greens." This method was fast and simple, but did not

TABLE I

SEASONAL UTILIZATION OF GREEN VEGETATION BY BOBWHITE QUAIL AS DETERMINED IN OTHER STUDIES AND EXPRESSED AS PERCENT VOLUME OF TOTAL CROP CONTENTS

Literature Reference	State Involved	Season and Percent Volume of Crop Contents			
		June-Aug.	Sept.-Nov.	Dec.-Feb.	March-May
Harshbarger and Buckner (1971)	Georgia	0	0.5	25.0	3.0
Robel (1969)	Kansas	no data	17.1	3.7	3.4
Eubanks (1972)	Tennessee	<0.5	0.5	<0.5	6.9
Baumgartner (1945)	Oklahoma	no data	1.6	4.3	no data
Davis (1964)	Oklahoma	no data	0.5	<0.5	no data

provide a quantitative estimate of succulents.

Each plot was assigned a number, and factors associated with the site were recorded. Relative amounts of organic litter, live herbaceous vegetation, and tree canopy were estimated and assigned values of low, medium, or high. Ground cover of 0-33 percent was low, 34-67 percent was medium, and 68-100 percent was high. These values were used in describing habitat types. Slope direction and degree were recorded for possible use in separating habitat according to physiographic characteristics. Plant species, common in the area, were recorded to aid in identifying seeds, nuts, and fruits in that sample.

Laboratory Procedures, Identification, and Classification of Food Items

Methods for storing and processing soil core and sweep net samples that would assure a minimum of weight change were selected. Sweep net samples were frozen at the laboratory and core samples were kept at room temperature out of sunlight. Sweep net samples were emptied into open trays and thawed before processing. Animal matter was then separated from plant debris, sorted into taxonomic groups with the aid of a binocular microscope, and set aside for weighing.

Soil core samples were removed from plastic bags and dried in shallow pans. Heat lamps were placed approximately 45 cm above the pans, and samples stirred occasionally to facilitate fast, even drying. Samples wer dried only enough to allow them to pass through a series o sieves with openings of 5 mm, 3 mm, 2 mm, 1.5 mm, and 1 mm In summer and fall many samples did not require drying.

Food material was separated from soil and debris in a four-step process. First the sample was run through the 5 mm and 1 mm screens. Material that did not pass through the 5 mm screen was immediately processed. All food items were removed and debris discarded. Material that passed through the 1 mm screen was discarded to speed up laborato analyses. Most quail foods were retained by the 1 mm screen; seeds with diameters less than 1 mm are rarely eaten by quail except in trace amounts.

The remainder of the core samples was placed in a South Dakota Seed Cleaner for removal of light organic debris and dust which allowed faster analyses and easier identification of seeds and other food items. The amount of air forced through the sample to remove light material could be varied so sound seeds and animal matter were not lost. Material blown out by the cleaner was collected and analyzed for food items. Seeds that were found in light debris were generally adapted to wind dissemination; no major quail foods are in this group. Therefore, it was assumed that all food material removed by the seed cleaner was of little importance as food for bobwhites.

Material remaining in the sample was screened through the 3 mm, 2 mm, 1.5 mm, and 1 mm sieves to separate the sample into size classes. Material in each size class was then separated by hand with the aid of a binocular microscope. Unsound seeds were discarded. Seeds with a hard seed coat were classified as sound if they withstood pressing with forceps without cracking or otherwise deforming (Bookhout 1958). Seeds without a hard seed coat were classified sound if pulp was present. Seeds and other food items taken from the soil cores were stored at room temperature out of direct sunlight until they could be identified and weighed.

Animal material from sweep net and soil core samples was sorted and identified to taxonomic order. Plant material was identified to genus and species if possible. Each taxonomic group was then weighed to the nearest 0.1 mg on a Metler electronic balance. Weighing was chosen because it was fast and provided the most acceptable means of expressing and comparing availability. Factors were calculated for converting raw data into kilograms of seeds and grams of arthropods per hectare.

Some foods that occurred in the samples may not be available to quail. Hurst (1970) believed that quail may not be able to capture and eat large arthropods. Therefore, those heavier than 0.35 gm dry weight were discarded. This procedure also helped minimize the effect of the sweep net oversampling large arthropods. Insects remaining were sorted and weighed. Only species in the taxonomic groups Arachnida, Hymenoptera, Diptera, Homoptera, Hemiptera, Coleoptera, and Orthoptera were considered important to quail (Hurst 1970). Food habits studies have supported this assumption (Davis 1964, Harshbarger and Buckner 1971, Parmalee 1953, Robel 1969). These catagories accounted fo: 92.0 percent of the arthropod biomass collected by the sweep net method. A similar procedure was used to separat‹ total and utilizable animal matter found in the soil core samples, except gastropods were included in the utilizable supply. Animal matter not considered utilizable by quail was assumed to have little importance.

Seeds were identified by comparing them to the seed collection of the Oklahoma Cooperative Wildlife Research Unit and by texts by Delorit (1970), Martin and Barkley (1961), Musil (1963), U.S. Department of Agriculture (1948] and Waterfall (1966). Nomenclature follows Fernald (1950).

Plant seeds were placed in two categories: (1) total supplies of seeds and (2) seeds important as quail foods. Total seed supplies included the seeds of all species founc in the core samples. Important quail foods included only foods consumed frequently by quail in Kansas, Oklahoma, and Texas (Barstow 1962, Baumgartner 1945, Baumgartner et al. 1952, Bird and Bird 1931, Hanson 1953, Parmalee 1955, Robel 1964, Robel 1969). Generally only a few foods compos the bulk of the bobwhite's diet. Five species made up 61 to 85 percent of the food consumed in each of the studies mentioned above (Table II). Species included as important foods were pigweed, western ragweed, giant ragweed,

TABLE II

RELATIVE IMPORTANCE OF QUAIL FOODS IN KANSAS, OKLAHOMA, AND TEXAS AS DETERMINED BY FOOD HABITS STUDIES

Literature Reference	Time Period	Locality	Food and Ranking Based on Percent Volume in Quail Crops				
			1	2	3	4	5
Baumgartner (1945)	Oct.-Dec.	Northcentral Oklahoma	sunflower	ragweeds	wild bean	sorghum	false buckwheat
Baumgartner, et al. (1952)	Nov.-Dec.	Stabilized dune N.W. Oklahoma	chittam-wood	sorghum	sunflower	sumpweed	ragweeds
Barstow (1962)	Nov.-Jan.	Texas Panhandle	croton	stickleaf mentzelia	erect dayflower	ragweed	pigweed
Bird and Bird (1931)	Dec.	Oklahoma	corn	ragweeds	sunflower	acorns	sorghum
Hanson (1953)	Nov.-Dec.	Sandsage N.W. Oklahoma	sorghum	ragweed	chittam-wood	sumpweed	spurge
Parmalee (1955)	Dec.-Jan.	Northcentral Texas	sorghum	euphorbia	browntop millet	buffalo bur	caltrop
Robel (1964)	Nov.-Apr.	Kansas	sorghum	sumac	partridge pea	corn	ragweeds
Robel (1969)	All Year	Kansas	sorghum	sunflower	ragweed	sumac	corn

chittamwood, partridge pea, sumpweed, prairie sunflower, panicums, paspalum, sorghum, wildbean, and wheat. These species presumably would provide the bulk of the diet of quail on the study area. Some early maturing species like panicums may be especially important during spring and summer periods not covered by most food habits studies and thus were included as important quail foods (Clark Derdeyn personal communication 1972).

Species diversity is an indication of community stability; a large number of species indicates a more stable system (Odum 1971). In order to maintain a stable system with only a few species, external forms of energy such as cultivation or tree thinning must be supplied (Odum 1971). The most stable habitats require the least energy input, through cultural practices, to maintain high levels of plant production. When increased quail food production is desired, management directed to produce stable systems would be most efficient. The total number of seed species found in each soil core sample was used to calculate species diversity among habitats.

Statistical Design

No attempt was made to stratify habitat types prior to selecting sampling locations because of extreme diversity of vegetation. Sampling locations were selected randomly throughout the entire study area. As each plot was located in the field, its habitat type was determined, and data obtained from that plot were combined with other data from the same habitat types.

Plot locations were determined using a 1:7920 scale aerial photograph and a table of random numbers. The 1.6C km square study area was divided in a grid pattern with 1C units on each side. Two consecutive two-digit numbers wer chosen from the table of random numbers and used as co-ordinates to locate a starting point on the aerial photograph. These coordinates were recorded in a field book, along with the distance and direction from the nearest, easily identifiable land mark.

The three digits immediately following the coordinate in the random numbers table were used to determine an azimuth. Five more consecutive three-digit numbers were taken from the table of random numbers and these represented the distances paced along the chosen azimuth from the starting point to five sampling plots. If any of the five sample plots did not fall within the study area they were located along the back azimuth beginning at the starting point. Using this method of locating plots, all points on the study area presumably had an equal probability of being sampled. This method reduced to a minimum the time required to locate plots in the field and made it possible to sample more plots.

Data were analyzed by habitats and seasons. Six vegetative communities were present: stabilized dunes, cottonwood bottomland, old disced strips, freshly disced areas, mature food plots, and upland woods. Stabilized dunes and upland woods are natural, vegetative types. The remaining types have been altered by man.

Plans were made to sample plots monthly from June 197 through May 1973. Heavy rains in late March and April 197 flooded the study area and prevented sampling in April and May. Samples were taken during the first week of each month. Thirty samples per month were all that could be analyzed in the available time, although analysis showed this number to be inadequate because of high variability. Samples were pooled and analyzed by season: summer (June-August), fall (September-November), winter (December-February), and spring (March). Numbers of samples representing the habitats were not equal or proportionate because the habitats were not equal in size. Seasons were not represented equally because of spring flooding. A two-way analyses of variance is extremely difficult when data cell sizes are not equal or proportionate (Snedecor and Cochran 1971). Therefore, data were analyzed one level of one factor at a time against all levels of the other factor, in a simple one-way analysis of variance (Snedecor and Cochran 1971). For example, data taken from plots in stabilized dunes were analyzed to determine effects of season as follows:

Source of Variation	Degrees of Freedom
145 samples	144
Variation due to seasons	3
Error	141

This procedure was used for all six habitat types. Likewise data taken during summer were analyzed to determine effects of habitat types as follows:

Source of Variation	Degrees of Freedom
80 samples	79
Variation due to 6 habitat types	5
Error	74

This procedure was followed for all seasons.

After analysis of variance was complete an F test was performed (Snedecor and Cochran 1971). If the F test indicated significant differences, the means were ranked and Duncan's Multiple Range Test was used to identify mean that were different (Steel and Torrie 1960). Tests were considered significant at the 95 percent level of confidence. In order to use these tests it was assumed that th data conformed to a normal distribution.

CHAPTER III

DESCRIPTION OF STUDY AREA

History, Location, and Physiographic Factors

The study area is part of a 16,677-acre public hunting area managed by the Oklahoma Department of Wildlife Conservation. It was purchased by the U.S. Army Corps of Engineers to store flood waters from the North Canadian River. Canton Lake was completed in 1948, and land surrounding the lake was turned over to the Department of Wildlife Conservation to develop wildlife resources. The public hunting area contains extensive plantings of crops and habitat improvements for wildlife. Commercial crops, chiefly sorghum and wheat, are grown on the area and harvested by sharecroppers who are supposed to leave approximately 40 percent of the crops in the field for wildlife (Carpenter 1970).

Field studies were conducted on Section 2, T19N, R14W of the public hunting area north of Canton Lake. Part of the southeast corner of the study area is cut off by the lake.

Several vegetative communities are present. Vegetated sand dunes occur north of the North Canadian River. Most of the bottomland between these dunes has undergone some habitat manipulation involving tree thinning or cultivation. Some upland sites are covered by blackjack oak and American elm. The amount of ground cover provided for various habitats by litter and herbaceous vegetation is indicated in Table III.

Good land use practices are extremely important to soil conservation in this area. In general this land does not lend itself to agricultural production due to the hilly relief, low fertility, low water-holding capacity, and susceptability to erosion. Grazing is the only advisable agricultural practice, and grazing rates must remain low in order to leave adequate vegetation for soil stabilization (Duck and Fletcher 1944). Grazing was not allowed on the study area.

Soils are the Tipton-Enterprise-Lincoln association (Steers, et al. 1963). Pratt soils cover the northwest quarter. Tivoli soils cover the remainder; these are deep, sandy soils subject to severe wind erosion when vegetation is removed by overgrazing or cultivation. The upper 25 cm of soil is porous and rapidly permeable, and underlain by uniform reddish-yellow, loose, fine sand that water and plant roots penetrate easily (Steers, et al. 1963). Vegetation normally stabilizes the dunes.

TABLE III

PERCENT OF PLOTS IN EACH HABITAT HAVING LIGHT, MEDIUM, OR HEAVY LITTER AND HERBACEOUS COVER, CANTON PUBLIC HUNTING AREA, NORTHWEST OKLAHOMA, 1972-73

Habitat Types	Percentage of Litter Ground Cover			Percentage of Herbaceous Ground Cover		
	Light	Medium	Heavy	Light	Medium	Heavy
Stabilized Dunes	34.5	60.0	5.5	20.7	65.5	13.8
Cottonwood Bottomland	4.4	70.6	25.5	72.1	25.0	2.9
Old Disced Strips	80.6	19.4	0	29.0	64.5	6.5
Freshly Disced Areas	100.0	0	0	84.2	10.5	5.3
Mature Food Plots	100.0	0	0	62.5	37.5	0
Upland Woods	0	27.3	72.7	100.0	0	0

Habitat Descriptions

Stabilized dunes comprise 50 percent of the area. Vegetation patterns on dunes depend on exposure of dune slopes. Some change in species composition is evident on different slope aspects, but the most striking change is the degree of vegetative cover. North and east slopes and draws between dunes tend to be much more heavily vegetated, apparently due to differences in microclimate, than do south and west exposures and dune tops. Areas void of plant litter or live vegetation occur frequently, especially on south and west exposures and dune tops. Vegetation or litter seldom appears heavy enough to restrict movement of quail (Table III). Vegetation is mainly herbacous, but scattered shrubs and trees occur also

Cottonwood bottomland constitutes 23.4 percent of the area and is located mainly in the southern part of the area. Terrain is flat and only a few meters above the water table. These bottomland areas contain dense stands of cottonwood and willow. In 1970 a bulldozer was used to remove approximately 50 percent of the overstory (Clark Derdeyn, personal communication 1971). The bulldozed debris was to be burned during the winter of 1971, but due to adverse weather was not. Partial removal of overstory, and soil disturbance from bulldozing and burning, presumably would encourage establishment of annuals that produce quail foods. However, the overstory rapidly closed during the first two years after treatment, and felled trees produced litter that made germination and establishment of annuals more difficult. Soils in the cottonwood bottomland are generally moist and rich in humus. Litter cover is moderate to heavy, being several centimeters thick in some cases, and could make foraging by quail difficult (Table III).

Old disced strips, areas which were disced at least one year prior to sampling and not disturbed since, composed 10.7 percent of the area. The strips were intended as fire breaks or food plots and are generally located in draws between dunes. Vegetation can be highly variable, depending on length of time since cultivation and on potentiality of the site. There is generally no tree cover. These areas should make good feeding sites for quail. The light litter cover and medium vegetative cover (Table III) provides protection and easy movement for foraging activities. Seeds on the soil surface should be relatively easy for quail to see.

Freshly disced strips, areas cultivated within the year prior to sample collection, comprised 6.6 percent of the area and are generally found in draws between dunes or on flat benches. Food plots where planted crops had not matured were also included in this category. Ground cover by litter and vegetation is generally light (Table III). Quail foods, if present, have apparently been covered by discing.

Mature food plots, consisting of areas planted to sorghum or wheat no more than one year prior to sampling, occupy 5.5 percent of the area. Ground litter and herbaceous cover is generally light (Table III). Mature food plots are considered ideal feeding habitat for quail, offering some overhead protection, abundant food, and easy movement.

Upland woods is the least extensive habitat (3.8 percent of the area) and is limited to upland benches and dry sites. The overstory is complete, and major species are blackjack oak and American elm. A relatively heavy understory and brush layer makes walking difficult. Ground litter is generally heavy; several centimeters of leaf litter cover the soil at most plots. Little or no herbaceous vegetation is present (Table III). Quail presumably have difficulty finding food items in the litter; however, upland woods may have value as cover during severe weather.

Climate

The area is characterized by extreme fluctuation of temperature, low irregular rainfall, high winds, high rate of evaporation, late summer drought, and a growing season exceeding 200 days (Bruner 1931). Temperatures appeared to be normal during the study. Precipitation was generally greater than average. The rainfall total for March (24.0 cm) was much above normal (2.5 cm) and caused flooding that terminated sampling (U.S. Department of Commerce 1973).

CHAPTER IV

RESULTS AND DISCUSSION

Total Seeds Available

Total availability of seeds was determined for comparison of habitats and seasons and for comparison with other availability studies. The total amount of seeds available ranged from 7.4 kg per ha on freshly disced areas in summer to 158.9 kg per ha for mature food plots in fall. Korschgen (1958) found a range of 26.9 kg per ha to 371.0 kg per ha in Missouri. Ripley and Perkins (1965) found a range of 2.2 to 20.8 kg per ha in Georgia. Bishop and Spinner (1946) showed seed availability ranging from 31.4 to 401.3 kg per ha in Connecticut. Total seed availability is affected by many factors including season, soil type, and vegetative cover (Baumgras 1943, Korschgen 1958, Ripley and Perkins 1965). Individual plots on the Canton Public Hunting Area had quantities of seeds ranging from 0.2 to 686.5 kg per ha. These extremes were found in stabilized dunes.

Only one habitat type, mature food plots, showed significant seasonal differences in total seed availability (Table IV). Summer and fall means were significantly

TABLE IV

MEAN KG PER HA, STANDARD ERROR, AND SAMPLE SIZE OF TOTAL SEED SUPPLIES BY SEASON AND HABITAT, CANTON PUBLIC HUNTING AREA, NORTHWEST OKLAHOMA, 1972-73

Habitat Types	Summer 1972	Fall 1972	Winter 1972-73	Spring 1973	Average
Stabilized Dunes	82.4±11.5(31)	63.7± 8.7(53)	41.5± 5.5(41)	87.3±33.8(20)	64.7(145)
Cottonwood Bottomland	65.0±10.5(27)	43.2±13.0(12)	76.2±10.6(24)	117.2±40.9(5)	69.0(68)
Old Disced Strips	74.5±15.2(8)	74.1±42.3(11)	99.5±37.6(8)	140.6±79.8(4)	89.3(31)
Freshly Disced Areas	7.4± 3.2(5)	25.6±13.1(7)	17.1± 5.7(6)	19.0(1)	17.8(19)
Mature Food Plots	90.5±21.9(7)	158.9±50.1(4)	16.9± 5.9(5)	no data	84.6(16)
Upland Woods	18.9± 6.2(2)	70.3±56.2(3)	101.9±63.5(6)	no data	78.2(11)

higher than the winter mean. Unfortunately, flooding prevented collecting samples from mature food plots in spring. Sorghum and wheat seeds had deteriorated by December, therefore, the availability of cultivated species would presumably have been lower in spring than in winter.

No significant differences existed between seasons in the stabilized dunes, cottonwood bottomlands, old disced strips, freshly disced areas, and upland woods. Sampling indicated large increases in seed supply in spring in stabilized dunes, cottonwood bottomland, and old disced strips. Late winter storms had knocked seeds of white sweetclover and American germander to the ground making them much more available during spring in stabilized dunes and cottonwood bottomland and accounting for increased seed productivity (Appendix B). Neither species is an important quail food.

One sample in the old disced strips in spring contained an unusually large number of bundleflower seeds. As a result, bundleflower accounted for 59.9 percent of all seeds (Appendix B). Due to the small sample size, this one sample indicated old disced strips had the highest average seed crop in spring. Bundleflower is sometimes found in quail crops although it is not considered an important quail food. The high sample variation prevented detection of seasonal differences.

In winter, the only season that showed statistically significant differences between habitats, mature food plots and freshly disced areas were significantly lower in seed availability than were old disced strips and upland woods (Table V). Unusually high incidences of American germande in old disced strips and hackberry in upland woods accounted for high availability values in these habitats during winter (Appendix B). The low values found in winte in freshly disced areas and mature food plots are similar and indicate the low production of natural foods in recently cultivated areas. When the data for all seasons were pooled, they showed significant differences between habitats. Similarity of means, except from freshly disced areas, indicated that freshly disced areas are significantly lower in availability of food (Table IV).

Seeds Important as Quail Food

Seeds commonly eaten by quail accounted for 20.9 percent of the total weight of all seeds collected. Other seeds might furnish additional food for quail; however, the bulk of the bobwhite's diet probably consists of species known to be important in this region. Average availability of seeds important to quail ranged from 1.2 kg per ha in upland woods in winter to 137.5 kg per ha in mature food plots in fall (Table VI). Individual samples ranged from 0 to 278.7 kg per ha, both extremes occurring in stabilized dunes. Korschgen (1958) found means from 11.8 to 151.4 kg per ha of "select" quail foods in Missouri. The low and high habitat means found by Korschgen (1958), in woodlands

TABLE V

DUNCAN'S MULTIPLE RANGE TEST OF VARIATION IN TOTAL SEED SUPPLY (kg/ha) IN HABITAT TYPES DURING WINTER, SEASONAL AVAILABILITY OF IMPORTANT QUAIL FOODS (kg/ha) IN MATURE FOOD PLOTS, AND NUMBERS OF SEED SPECIES IN FRESHLY DISCED AREAS BY SEASON, CANTON PUBLIC HUNTING AREA, NORTHWEST OKLAHOMA, 1972-73. MEANS UNDERSCORED BY THE SAME LINE ARE NOT SIGNIFICANTLY DIFFERENT FROM EACH OTHER.

Duncan's Multiple Range Test

Total Seed Supply In Habitat Types During Winter 1972-73

Mature Food Plots	Freshly Disced Areas	Stabilized Dunes	Cottonwood Bottomland	Old Disced Strips	Upland Woods
16.9	17.1	41.5	76.2	99.5	101.9

Seasonal Availability Of Important Quail Foods In Mature Food Plots

Winter 1972-73	Summer 1972	Fall 1972
7.2	53.6	137.5

Numbers Of Seed Species In Freshly Disced Areas By Season

Summer 1972	Fall 1972	Winter 1972-73	Spring 1973
3.6	4.6	8.7	10.0

TABLE VI

MEAN KG PER HA, STANDARD ERROR, AND SAMPLE SIZE OF SEEDS IMPORTANT FOR QUAIL FOOD BY SEASON AND HABITAT, CANTON PUBLIC HUNTING AREA, NORTHWEST OKLAHOMA, 1972-73

Habitat Types	Summer 1972	Fall 1972	Winter 1972-73	Spring 1973	Average
Stabilized Dunes	8.1± 1.8(31)	17.9± 5.5(53)	18.7±4.6(41)	11.4±4.6(20)	15.1(145)
Cottonwood Bottomland	3.7± 0.9(27)	8.0± 4.5(12)	8.5±2.2(24)	9.3±5.7(5)	6.6(68)
Old Disced Strips	8.5± 3.3(8)	7.8± 2.5(11)	15.5±7.0(8)	3.6±1.9(4)	9.4(31)
Freshly Disced Areas	3.6± 2.1(5)	12.6± 7.1(7)	4.1±1.1(6)	8.6(1)	7.3(19)
Mature Food Plots	53.6±15.7(7)	137.5±44.3(4)	7.2±3.4(5)	no data	60.1(16)
Upland Woods	1.5± 1.5(2)	5.4± 3.2(3)	1.2±0.8(6)	no data	2.4(11)

and harvested cornfields respectively, were in habitats similar to those showing low and high means in this study.

Significant statistical differences occurred between habitats during summer and fall. Duncan's Test indicated that the amount of seeds important to quail was significantly greater in mature food plots than in all other habitat types in both summer and fall. No significant differences existed between the other five habitat types in either season. Sorghum and wheat provided 70.4 percent of the total weight of seeds found in food plots in summer and fall. There were no differences between habitats in the weight of seeds important to quail in winter and spring (Table VI). The percent (by weight) of cultivated species in mature food plots dropped to 4.3 percent of the weight of seeds important to quail during winter. In winter, when cultivated species were not important sources of food, stabilized dunes contained the greatest quantity of seeds important as quail food although the difference was not statistically significant.

Differences in seed availability at various seasons were significant only in mature food plots (Table V). Mean for fall and winter are significantly different. Wheat sown in fall and winter, 1971, provided seed in summer, 1972. Abundance of wheat declined sharply by fall, 1972. Sorghum planted in spring matured during fall, 1972. Sorghum and the remaining wheat provided the largest supply of seeds important to quail in fall. Very few seeds of cultivated species remained by winter; their supplies were depleted by utilization and deterioration. The trend in declining food availability in food plots would presumably continue through spring because small grains planted there would not mature until June.

This research points to a basic flaw in the use of cultivated crops to increase the food base for wildlife. Food plots were not providing food at a time when availability of native foods was low because crops matured too early and their seeds deteriorated too rapidly. Species planted in food plots in the study area could not be counted on to provide quail food from December to June. This same problem was noted by Eubanks (1972) for certain species used in food plots in west Tennessee.

Winter wheat did provide quail food during summer. Quail foods became scarcest in most habitat types in summer (Table VI). Consequently, mature wheat in food plots may be a very important food source for nesting birds and young broods in summer. Native plants are relatively abundant during fall and the need for cultivated species then is questionable.

Stabilized dunes have the greatest amount of important quail foods available annually if mature food plots are ignored (Table VI). Total availability of seeds in stabilized dunes was consistently high in all seasons and was 60 to 500 percent greater than in any other habitat type.

Stabilized dunes illustrate seasonal changes in food availability. More samples were taken in stabilized dunes than in any other type of habitat, therefore, their seasonal means should be most accurate. Seed supply was lowest in summer, but increased by more than 100 percent during fall as seeds matured and dropped to the ground. The supply remained fairly constant through winter. Utilization and deterioration depleted the seed supply, causing a 40 percent decrease from winter to spring.

Native foods such as western ragweed, sumpweed, and the panicums were found in quantity in all seasons includir spring and summer when food supplies were at their lowest point (Table VI). Thus, management activities designed to increase production of native quail foods would be most beneficial. Winter wheat might be important in food plots during summer. Although mature food plots contained 23.7 percent of the total weight of all seeds important to quail the poor seasonal distribution of availability decreases their importance as producers of quail food. However, heavy consumption of small grain, especially sorghum, by quail in fall (Table II) may preserve native foods for winter and spring.

Invertebrates Important as Quail Food in Soil Core Samples

Animals found in soil cores were mainly gastropods and arthropods. Crustaceans, principally sow bugs, were excluded from analyses because they were seldom eaten by quail. Animals commonly eaten by quail comprised 44.8 per cent of the total invertebrates found. Supplies of animal were generally lower than supplies of seeds. The average amount of animal life available in habitats at various seasons ranged from 0 to 3.2 kg per ha. The low mean occurred frequently (Table VII); the high was recorded during summer in cottonwood bottomland. The individual sample high was 18.9 kg per ha in cottonwood bottomland.

No significant differences existed between habitats during any season. Samples from cottonwood bottomland consistently contained the highest supplies of invertebrate important as quail food and had the highest annual average (Table VII). This was expected because the type's moist soil and high organic matter content probably had the best environment for ground-dwelling insects.

Significant seasonal differences were found in stabilized dunes. Duncan's Test could not be used to pick out differences due to high standard error. Spring had the highest supply (2.9 kg per ha); summer was next (1.9 kg per ha). Supplies in fall and winter were only 0.9 and 0.7 kg per ha respectively. Availability of animal matter was expected to fluctuate as it did in cottonwood bottomland with winter having the lowest supply, fall and spring approximately equal, and summer having the highest supply. Great numbers of small individuals partially explained the high availability in spring in stabilized dunes. In

TABLE VII

MEAN KG PER HA, STANDARD ERROR, AND SAMPLE SIZE OF GROUND-DWELLING INVERTEBRATES IMPORTANT AS QUAIL FOOD BY SEASON AND HABITAT, CANTON PUBLIC HUNTING AREA, NORTHWEST OKLAHOMA, 1972-73

Habitat Type	Summer 1972	Fall 1972	Winter 1972-73	Spring 1973	Average
Stabilized Dunes	1.9±0.6(31)	0.9±0.3(53)	0.7±0.2(41)	2.9±0.8(20)	1.3(145)
Cottonwood Bottomland	3.2±0.9(27)	2.6±1.1(12)	1.5±0.5(24)	2.7±2.2(5)	2.5(68)
Old Disced Strips	3.0±1.1(8)	2.0±0.6(11)	1.4±0.9(8)	1.0±1.0(4)	2.0(31)
Freshly Disced Areas	0(5)	0.2±0.2(7)	0.7±0.7(6)	0(1)	0.3(19)
Mature Food Plots	<0.1(7)	<0.1(4)	0(5)	no data	0(16)
Upland Woods	1.3±1.2(2)	0(3)	1.3±0.8(6)	no data	1.0(11)

contrast, many insects had reached full development by summer and exceeded the 0.35 gm maximum weight that quail can utilize.

Mature food plots and freshly disced areas contained almost no invertebrates important as quail food (Table VII The limited ground cover on these types permitted extremes of soil temperature and low soil moisture conditions and consequently an inhospitable environment for invertebrate life.

The weight of invertebrates important as quail food i upland woods was relatively small (Table VII). Soil tempe ature extremes were buffered by dense vegetative cover, bu low soil moisture normally associated with these sites (Steers, et al. 1963) may have restricted invertebrate populations. The low sample size may have inaccurately depicted invertebrate populations in this habitat type.

Arthropods Important as Quail Food in Sweep Net Samples

Arthropods important as quail foods collected in sweep net samples accounted for 92.0 percent of the total arthropods that weighed less than 0.35 gm. Seasonal-habitat means ranged from 0 in several habitats during winter, to 83.9 gm per ha found during summer in old disced strips (Table VIII). The largest invertebrate population sampled was 557.9 gm per ha in cottonwood bottomland.

TABLE VIII

MEAN GM PER HA, STANDARD ERROR, AND SAMPLE SIZE OF PLANT-DWELLING ARTHROPODS IMPORTANT AS QUAIL FOOD BY SEASON AND HABITAT, CANTON PUBLIC HUNTING AREA, NORTHWEST OKLAHOMA, 1972-73

Habitat Type	Summer 1972	Fall 1972	Winter 1972-73	Spring 1973	Average
Stabilized Dunes	82.0±13.3(30)	62.4± 6.4(48)	0.3±0.2(14)	no data	59.4(92)
Cottonwood Bottomland	44.1±20.5(27)	64.6±29.5(10)	0.5±0.2(7)	no data	41.7(44)
Old Disced Strips	83.9±32.3(7)	58.5±14.9(10)	0.6±0.3(3)	no data	58.7(20)
Freshly Disced Areas	27.7±16.9(5)	49.9±31.6(3)	0(3)	no data	26.2(11)
Mature Food Plots	52.0±45.7(4)	39.8±14.3(3)	0(1)	no data	40.9(8)
Upland Woods	54.9±16.7(2)	35.3± 1.3(3)	0(2)	no data	30.8(7)

Hurst (1970) found a range of 355.7 to 573.0 gm per ha in a relatively homogeneous habitat during summer in Mississippi.

Significant differences were not found between habitat in any season. The averages for habitats tend to be simila in all seasons (Table VIII). Stabilized dunes had the highest average (59.4 gm per ha) and freshly disced areas the lowest (26.2 gm per ha). These figures corroborate evidence that natural dune habitat may be the most consistent producer of food for bobwhite quail.

Seasonal variation within each habitat was consistent and predictable. Only stabilized dunes and upland woods showed significant seasonal differences (Table VIII). Values obtained for summer and fall were similar. Few or no invertebrates were available to quail in any habitat in winter. In stabilized dunes and upland woods the average biomass of invertebrates in summer and fall were not significantly different. The winter average was significantly different from that for summer and fall in both habitats, according to Duncan's Test.

Sweep net sampling was discontinued after December because few arthropods were available. Some preliminary sweep net samples were taken in March to determine if availability had increased enough to justify sampling. Availability was no greater than in winter, so sampling was not completed in March. The latter observation appears to conflict with the relative high availability of invertebrates important as quail food found in soil cores during spring (Table VII). Samples not representati' of the true situation might be blamed. Few insects were observed on plants while soil cores were collected in spring. Therefore, the results of the preliminary sweep net samples taken in March are believed to be representati' of the true availability.

An interesting change occurred in the kinds of arthro· pods available in the six habitats through the seasons. During summer Coleoptera and Orthoptera comprised most of the arthropod biomass except in upland woods where arachni(were more important (Appendix C). Hemiptera were the most important arthropod found in all habitats in fall except i1 upland woods. Only Hymenoptera, Diptera, and Homoptera were found during winter. Coleoptera and Orthoptera often grow large enough to exceed the 0.35 gm individual weight limit chosen for this study, thus many were removed from the samples. Oversize insects were especially prevalent in the fall, at least partially explaining the decline in importance of Coleoptera and Orthoptera from summer to fall

Frequency of Occurrence of Succulent Vegetation

Frequency of occurrence of greens ranged from 0 to 100 percent for individual plots with averages of 0 to 57.5 percent for habitat types at various seasons (Table IX). Woodland types and mature food plots frequently contained

TABLE IX

PERCENT FREQUENCY OF OCCURRENCE, STANDARD ERROR, AND SAMPLE SIZE OF GREEN VEGETATION BY SEASON AND HABITAT, CANTON PUBLIC HUNTING AREA, NORTHWEST OKLAHOMA, 1972-73

Habitat Types	Summer 1972	Fall 1972	Winter 1972-73	Spring 1973	Average
Stabilized Dunes	22.5± 3.8(31)	32.5± 3.8(53)	32.5± 5.0(41)	57.5± 8.8(20)	33.8(145)
Cottonwood Bottomland	6.3± 5.0(27)	0(12)	1.3± 0.0(24)	0(5)	3.8(68)
Old Disced Strips	31.3±12.5(8)	31.3±10.0(11)	6.3± 3.8(8)	35.0±16.3(4)	25.0(31)
Freshly Disced Areas	12.5±12.5(5)	42.5±15.0(7)	28.8±12.5(6)	87.5(1)	32.5(19)
Mature Food Plots	12.5± 8.8(7)	10.0± 6.3(4)	0(5)	no data	7.5(16)
Upland Woods	0(2)	21.3±21.3(3)	0(6)	no data	6.3(11)

little or no green vegetation. The high mean was found during winter in stabilized dunes (Table IX).

Significant differences were found between means of at least two habitats in most seasons (Table IX). Old disced strips and upland woods differed significantly during summer with means of 31.5 and 0 percent respectivel Freshly disced areas (42.5 percent) differed significantly from cottonwood bottomland (0 percent) in fall. High standard error prevented Duncan's Test from determining which means were different in winter. The means for stabilized dunes (32.5 percent) and freshly disced areas (28.8 percent) were considerably higher than the means for the other habitat types during winter.

Only the stabilized dunes showed significant differences in the availability of greens between seasons (Table IX). Standard error was again too high to determine which seasons were different. The highest mean occurred in spring (57.5 percent), fall and winter seasons were identical (32.5 percent), and the summer season had the lowest mean (22.5 percent). This seasonal trend was expected because summer is the hottest and dryest part of the year, making seed germination and development difficult then. Spring should have ideal temperature and moisture conditions, and therefore, have the best conditions for plant germination and development.

The average occurrence of green vegetation for each habitat showed that stabilized dunes, old disced strips, and freshly disced areas had similar means (Table IX). These three types have much higher frequencies of green vegetation than do cottonwood bottomland, mature food plot and upland woods. The woodland types would not be expecte to have much young green material because their dense overstory allows very little light to reach the forest floor. Most plants in mature food plots are annuals that have already reached maturity. When cultivated crops mature, the fairly heavy herbaceous cover inhibits germination and development of other species. The stabilized dune type was the highest and most consistent producer of greens, again indicating the importance of natural habitat for production of food for quail.

Number of Species Found in Soil Core Samples

The mean number of species for each habitat was surprisingly consistent (Table X). The low mean (3.6) occurred in freshly disced areas during summer. The high mean (9.5) was found during spring in old disced strips. Individual plot extremes were 18 species found in stabilize dunes; only one species occurred in several habitats. Significant differences were found between habitats during summer and fall, although standard error was too high to use Duncan's Test (Table X). Stabilized dunes, old disced strips, mature food plots, and upland woods had the highest average for species diversity. Cottonwood bottomland and

TABLE X

NUMBER OF SPECIES, STANDARD ERROR, AND SAMPLE SIZE FOR SEEDS FOUND IN SOIL CORES BY SEASON AND HABITAT, CANTON PUBLIC HUNTING AREA, NORTHWEST OKLAHOMA, 1972-73

Habitat Types	Summer 1972	Fall 1972	Winter 1972-73	Spring 1973	Average
Stabilized Dunes	7.5±0.5(31)	7.4±0.4(53)	7.9±0.6(41)	7.5±0.6(20)	7.6(145)
Cottonwood Bottomland	5.1±0.6(27)	4.9±0.7(12)	6.7±0.6(24)	5.4±0.6(5)	5.7(68)
Old Disced Strips	7.3±0.9(8)	7.0±0.7(11)	7.8±0.8(8)	9.5±1.7(4)	7.6(31)
Freshly Disced Areas	3.6±1.3(5)	4.6±0.8(7)	8.7±1.3(6)	10.0(1)	5.9(19)
Mature Food Plots	7.4±2.0(7)	8.0±1.7(4)	7.0±0.7(5)	no data	7.4(16)
Upland Woods	6.0±1.0(2)	7.0±1.5(3)	6.3±1.4(6)	no data	6.5(11)

freshly disced areas consistently contained fewer species presumably because both had been altered by man. Old disced strips had experienced at least one growing season since disturbance and were approaching natural conditions. The high number of species consistently found in mature food plots was surprising. However, this type had also been through one growing season and ground cover from the cultivated species might have aided establishment of other species.

Numbers of species increased during winter and spring in the cottonwood bottomland and freshly disced areas (Table X). No significant differences were found between habitats in winter or spring because of these increases. Cottonwood bottomland still contained fewer seed species than the other types. Freshly disced areas had a mean number of species similar to old disced strips. Many freshly disced areas had completed one growing season, seed species had matured and became available by winter. The change in the numbers of species in freshly disced areas from summer to spring was statistically significant (Table V).

Stabilized dunes, old disced strips, and mature food plots had the greatest average number of seed species; upland woods, freshly disced areas, and cottonwood bottomland had fewer. Stabilized dunes are among the most stable habitats and require the least energy input, through cultural practices, to maintain production.

Sample Sizes Required for Availability Studies

A study of foods available for wildlife can be valuab for evaluating management practices and determining steps necessary for improving habitat. However, the variation encountered in sampling can be frustrating. The only solution is large sample sizes. Unless individual habitat types are homogeneous, a few samples from each type will not be sufficient to provide an accurate estimate of food availability and can lead to erroneous conclusions. Unfortunately, sampling and processing the food items is time consuming.

Sample sizes were calculated for various statistical levels of confidence based on 145 soil core samples taken from June, 1972, through March, 1973, in stabilized dunes and analyzed for total seed availability. Sample size was determined by the formula $N = \frac{t^2 s^2}{(z\bar{x})^2}$ (Steel and Torrie 1960) for levels of confidence from 50 to 99 percent and for values within 50 to 1 percent of the sample mean (Table XI). The formula is designed to determine sample sizes necessary to achieve a certain level of accuracy within a population and not designed to determine sample sizes required to test for significant differences between populations. Formulae are not available to determine sample sizes required to detect differences between populations where it is impossible to obtain an equal number of samples from each population.

TABLE XI

SAMPLE SIZES REQUIRED FOR VARIOUS CONFIDENCE LEVELS IN STUDIES OF SEEDS PRESENT IN SOIL CORES IN STABILIZED DUNES, CANTON PUBLIC HUNTING AREA, NORTHWEST OKLAHOMA, 1972-73

Allowable Error Expressed As a Percent of the True Population Mean	Statistical Level of Confidence					
	50%	60%	80%	90%	95%	99%
50	3	4	9	16	22	39
40	4	6	15	25	35	61
20	16	25	59	98	139	242
10	65	101	236	391	556	969
5	260	405	944	1,563	2,222	3,877
1	6,502	10,130	23,603	39,068	55,557	96,915

Four to 6 man-hours of work were required for complet analysis of each sample taken in my study. This includes field, laboratory, and data analyses time. The stabilized dune habitat type is quite diverse and the numbers of samples required to obtain a specified level of accuracy would be greater for that type than for most habitats. Table XI should give a researcher a fair estimation of the accuracy he can expect to obtain with the time and help available to him.

CHAPTER V

SUMMARY

This study was designed to determine kinds and amounts of foods available for bobwhite quail and nutritional quality of the most important foods on Canton Public Hunting Area in northwest Oklahoma.

Seeds make up the largest percentage of foods eaten by bobwhite quail. Total seed availability ranged from 7.4 to 158.9 kg per ha. The lowest seed availability occurred on freshly disced areas during summer and the highest occurred in mature food plots during fall. Total seed supply was not significantly different in habitat types at various seasons except in mature food plots that had considerably lower seed availability during winter. Freshly disced areas contained a significantly lower weight of seeds annually than any other habitat type.

Species of seeds commonly eaten by quail accounted for 20.9 percent of the total seed weight. Availability of these important quail foods ranged from 1.2 kg per ha in upland woods during winter to 137.5 kg per ha in mature food plots during fall. Mature food plots had significantly greater amounts of important quail foods available than other habitat types during summer and fall. Sorghum and wheat accounted for 70.4 percent of the weight of seeds commonly eaten by quail in these seasons.

Availability of cultivated species declined sharply i winter because of utilization by quail and other seed eating birds and mammals and deterioration. Sorghum and wheat accounted for only 4.3 percent of the weight of seed commonly eaten by quail, in mature food plots and only 0.1 percent of important quail foods from all habitats. Availability of seeds from cultivated species was low from December to June, a critical time for quail. Wheat may be important food during summer for birds engaged in nesting and brood rearing. In fall, when availability of seeds of cultivated species in mature food plots is highest, the availability of seeds from native species is also higher, therefore the cultivated species may not be needed during this period.

Few seeds of wheat and sorghum are available in mature food plots during winter, and stabilized dunes contain the largest quantities of important quail foods. If food plots are ignored, stabilized dunes annually contain the greatest amount of important quail foods. Seeds from wild plants remained sound through winter, continually providing food for quail. In contrast, seeds from cultivated species deteriorated rapidly because they lacked a weather resistant seed coat.

Arthropods and crustaceans are utilized by quail less often than are seeds and are less available. The largest weight of arthropods observed was 3.2 kg per ha in cottonwood bottomlands. This type consistently contained more arthropods and crustaceans than other habitats, although significant differences were not detected between habitats in any season. Cultivated habitat types were consistently low in the availability of animal matter that could be utilized by quail, possibly because of a harsh microclimate and a lack of green vegetation for invertebrates to feed on. A definite seasonal trend was observed in the availability of animal matter, winter had the lowest supplies, summer was highest, and fall and spring had intermediate amounts.

Succulent green vegetation is frequently found in small amounts in quail crops. There appeared to be no lack of this food source in any habitat or in any season. Stabilized dunes had the highest frequency of occurrence of "greens", old disced strips and freshly disced areas had only slightly fewer greens. Seasonal differences within habitats were small.

This study indicates that stabilized dunes have the largest supply of quail foods. Food plots provide much food in a small area but at a time of year when natural foods are most abundant. Food plots are deficient in food when natural foods are least abundant. Native seed species resisted deterioration much better than cultivated species and provided food throughout the year. The most efficient management practices would be those designed to increase seed production by the commonly eaten, native quail foods.

Discing strips and planting them to winter wheat seem to be a promising management practice. Mature winter wheat provides food for quail involved in nesting and brood rearing. These strips could then be allowed to revert to natural vegetation. New strips could be disced and planted each fall and the process repeated. This practice would increase the amount of edge and make available many successional stages for satisfying the habitat requirements of quail. If cultivated species are used, careful consideration must be given to the time of year when their seeds will be available to quail.

Plant species that are perennial seed producers should be given prime consideration for planting in food plots because they require the least energy input for maintenance. Bicolor lespedeza has been successfully used in the southeast (McConnell 1965, Rosene 1956) because of its heavy seed production, nutritional value, and presistance of seeds into late winter and spring. However, bicolor lespedeza may not be able to endure the low moisture conditions common in the Canton Public Hunting Area. A good evaluation of plants that would be suitable for food production for wildlife and for soil stabilization in northwest Oklahoma is presented by Hanson (1953).

Species that seed in late fall or early winter and resist deterioration might increase the number of quail surviving through winter and thereby provide an increased breeding population. The latter recommendation assumes that food may limit the size of quail populations and that all other habitat requirements are present in sufficient quantities to meet the needs of quail.

LITERATURE CITED

Barstow, C. J. 1962. Winter food habits of the bobwhite quail (Colinus virginianus) on the Gene Howe Wildlife Management Area, Hemphill County, Texas, December 1955 and January 1956. MS Thesis, Oklahoma State University, Stillwater. 35 p.

Baumgartner, F. M. 1945. Bobwhite food relations to land use in northcentral Oklahoma. Trans. Texas Acad. Sci. 29:234-239.

Baumgartner, F. M., M. J. Morris, S. L. Steel, and J. E. Williams. 1952. Oklahoma bobwhite food relations. Trans. N. Amer. Wildl. Conf. 17:338-358.

Baumgras, P. S. 1943. Winter food productivity of agricultural land for seed-eating birds and mammals. J. Wildl. Manage. 7(1):13-18.

Bird, L. G., and R. D. Bird. 1931. Winter food of Oklahoma quail. Wilson Bull. 43:293-305.

Bishop, J. S., and G. P. Spinner. 1946. Quantities of weed seed produced in Connecticut cornfields. J. Wildl. Manage. 10(4):300-303.

Bookhout, T. A. 1958. The availability of plant seeds to bobwhite quail in southern Illinois. Ecology 39(4):671-681.

Bruner, W. E. 1931. The vegetation of Oklahoma. Ecol. Monogr. 1:99-188.

Burger, G. V., and J. P. Linduska. 1967. Habitat management related to bobwhite populations at Remington Farms. J. Wildl. Manage. 31(1):1-12.

Carpenter, J. W. 1970. Food habits of the mourning dove in northwest Oklahoma. MS Thesis, Oklahoma State University, Stillwater. 67 p.

Davis, C. A. 1964. Components of the habitat of the bobwhite quail in Payne County, Oklahoma. Ph.D. Thesis, Oklahoma State University, Stillwater. 150 p.

Davison, V. E. 1949. Bobwhite on the rise. Chas. Scribner's Sons, New York. 150 p.

Delorit, R. J. 1970. Illustrated taxonomy manual of weed seeds. Agronomy Publications, River Falls, Wisconsin. 175 p.

Duck, L. C., and J. Fletcher. 1947. A survey of the game and furbearing animals of Oklahoma. Oklahoma Game an Fish Commission, P-R Project, Series 2. 144 p.

Eubanks, T. R. 1972. Food habits of bobwhite quail (Colinus virginianus) on Ames Plantation in west Tennessee. MS Thesis, University of Tennessee. 88 p.

Fernald, M. L. 1950. Gray's manual of botany, 8th Ed., American Book Co., New York. 1632 p.

Hanson, W. R. 1953. Plants for improving land use and bobwhite habitat in northwestern Oklahoma. Ph.D. Thesis, Oklahoma A. and M. College, Stillwater. 136]

Harshbarger, T. J., and J. L. Buckner. 1971. Quail foods in Georgia flatwoods. Georgia Forest Research Paper 68. 5 p.

Haugen, A. O., and F. W. Fitch. 1955. Seasonal availability of certain bush lespedeza and partridge pea seed as determined from ground samples. J. Wildl. Manage. 19(2):297-301.

Hurst, G. A. 1970. The effects of controlled burning on arthropod density and biomass in relation to bobwhite quail (Colinus virginianus) brood habitat. Ph.D. Thesis, Mississippi State University. 61 p.

Korschgen, L. J. 1958. Availability of fall game bird food in Missouri topsoil. P-R Series No. 16. Missouri Conservation Commission, Jefferson City. 36 p.

Larimer, E. J. 1960. Winter foods of the bobwhite in southern Illinois. Illinois Natural History Survey Biological Notes 42. 35 p.

Larson, J. S. 1967. Forests, wildlife and habitat management--a critical examination of practice and need. U.S. Forest Service Research Paper SE-30. 28 p.

Lehmann, V. W. 1953. Bobwhite population fluctuations and vitamin A. Trans. N. Amer. Wildl. Conf. 18:201-246.

Martin, A. C., and W. D. Barkley. 1961. Seed identification manual. University of California Press, Berkley 221 p.

McConnell, C. A. 1965. An evaluation of the utilization of bobwhite quail food plants on an established management area. MS Thesis, Auburn University, Auburn, Alabama. 51 p.

Murray, R. W. 1958. The effect of food plantings, climatic conditions, and land use practices upon the quail population on an experimental area in northwest Florida. Proc. Annu. Southeastern Assoc. Game and Fish Comm. 12:269-274.

Musil, A. F. 1963. Identification of crop and weed seeds U.S. Department of Agriculture, Agriculture Handbook No. 219. 171 p.

Nestler, R. B. 1946. Vitamin A, vital factor in the survival of bobwhites. N. Amer. Wildl. Conf. 11:176-192.

Odum, E. P. 1971. Fundamentals of ecology. W. B. Saunders Co., Philadelphia. 574 p.

Parmalee, P. W. 1953. Food and cover relationships of the bobwhite quail in east-central Texas. Ecology 34(4):758-770.

Parmalee, P. W. 1955. Notes on the winter foods of bobwhites in northcentral Texas. Texas J. Sci. 7(2):189-195.

Ripley, T. H., and C. J. Perkins. 1965. Estimating ground supplies of seed available to bobwhites. J. Wildl. Manage. 29(1):117-121.

Robel, R. J. 1964. Fall and winter food habits of 150 bobwhite quail in Riley County, Kansas. Trans. Kansas Acad. Sci. 66(4):778-789.

Robel, R. J. 1969. Food habits, weight dynamics, and fat content of bobwhites in relation to food plantings in Kansas. J. Wildl. Manage. 33(2):237-247.

Robel, R. J., and N. A. Slade. 1965. The availability of sunflower and ragweed seeds during fall and winter. J. Wildl. Manage. 29(1):202-206.

Rosene, Walter, Jr. 1956. An appraisal of bicolor lespedeza in quail management. J. Wildl. Manage. 20(2):104-110.

Rosene, Walter, Jr. 1969. The bobwhite quail: its life and management. Rutgers University Press, New Brunswick. 418 p.

Snedecor, G. W., and W. G. Cochran. 1971. Statistical methods. The Iowa State University Press, Ames. 593 p.

Steel, R. G. D., and J. H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill Book Co., Inc. New York. 481 p.

Steers, C. A., J. W. Frie, and E. S. Grover. 1963. Soil survey: Dewey County, Oklahoma. U.S. Department of Agriculture, Soil Conservation Service, Series 160, No. 9. 80 p.

Stoddard, H. L., Sr. 1950. The bobwhite quail: its habits, preservation and increase. Chas. Scribner's Sons, New York. 559 p.

U.S. Department of Agriculture, Forest Service. 1948. Woody-plant seed manual. U.S. Department of Agriculture, Miscellaneous Publication No. 654. 416 p.

U.S. Department of Commerce. 1973. Climatological data, Oklahoma. 82(3):1-22.

Waterfall, U. T. 1966. Keys to the flora of Oklahoma. Oklahoma State University, Stillwater. 243 p.

APPENDIX A

COMMON AND SCIENTIFIC NAMES OF PLANT SPECIES USED IN THESIS, NOMENCLATURE FOLLOWS FERNALD (1950)

Acacia, prairie	*Acacia angustissima*
Acorns	*Quercus* spp.
Barnyard grass	*Echinochloa crus-galli*
Bluestem	*Andropogon* spp.
Bristlegrass	*Setaria* sp.
Brome	*Bromus* sp.
Buckbrush	*Symphoricarpus orbiculatus*
Buffalo bur	*Solanum rostratum*
Bulrush	*Scirpus* spp.
Bundleflower	*Desmanthus illinoensis*
Caltrop	*Tribulus terrestris*
Camphorweed	*Heterotheca subaxillaris*
Chittamwood	*Bumelia lanuginosa*
Corn	*Zea mays*
Cottonwood	*Populus deltoides*
Crabgrass, hairy	*Digitaria sanguinalis*
Dayflower, erect	*Commelina erecta*
Doveweed	*Croton* spp.
Elm, American	*Ulmus americana*
Euphorbia	*Euphorbia* spp.
False buckwheat	*Polygonum scandens*
Flatsedge	*Cyperus* spp.
Geranium, Carolina	*Geranium carolinianum*
Germander, American	*Teucrium canadense*
Goat's beard	*Tragopogon* sp.
Goosefoot	*Chenopodium* spp.
Grape	*Vitis aestivalis*
Gromwell	*Lithospermum* sp.
Ground cherry	*Physalis* sp.
Hackberry	*Celtis reticulata*
Indigobush	*Indigofera leptosepala*
Johnsongrass	*Sorgum halepense*
Lespedeza, bicolor	*Lespedeza bicolor*
Lespedeza, roundhead	*Lespedeza capitata*
Love-grass	*Eragrostis* sp.
Mallow	*Sida* sp.

APPENDIX A (Continued)

Mentzelia, stickleaf	*Mentzelia oligosperma*
Milkweed	*Asclepias* sp.
Millet	*Panicum* spp.
Mullein	*Verbascum* sp.
Nettle	*Urtica* sp.
Nightshade	*Solanum* sp.
Oak, blackjack	*Quercus marilandica*
Panic grass	*Panicum capillare* & *dichotomiflo*
Panicum, scribner	*Panicum oligosanthes*
Panicum	*Panicum* spp.
Partridge pea	*Cassia fasciculata*
Paspalum, sand	*Paspalum setaceum*
Peppergrass	*Lepidium* sp.
Pigweed	*Amaranthus retroflexus*
Plaintain, bracted	*Plantago aristata*
Plum, sand	*Prunus angustifolia*
Polygonum	*Polygonum* spp.
Prickly poppy	*Argemone intermedia*
Ragweed, giant	*Ambrosia trifida*
Ragweed, western	*Ambrosia psilostachya*
Rose, multiflora	*Rosa multiflora*
Sandbur, field	*Cenchrus pauciflorus*
Sedge	*Carex* spp.
Sorghum	*Sorgum vulgare*
Soybean	*Glycine max*
Spikerush	*Eleocharis* sp.
Spurge	*Euphorbia* spp.
Stick-tight	*Bidens* sp.
Sumac	*Rhus* sp.
Sumpweed	*Iva cilata*
Sunflower, prairie	*Helianthus petiolaris*
Sunflower	*Helianthus* spp.
Sweetclover, white	*Melilotus alba*
Tick-clover	*Desmodium sessilifolium*
Thistle, common	*Cirsium* sp.
Vervain	*Verbena bracteata*
Vetch	*Vicia* spp.
Wheat	*Triticum aestivum*
Wildbean	*Strophostyles* spp.
Willow	*Salix nigra*
Witchgrass, fall	*Leptoloma cognatum*

APPENDIX B

PERCENT WEIGHT AND PERCENT OCCURRENCE OF

SEEDS BY HABITAT TYPE, CANTON PUBLIC

HUNTING AREA, NORTHWEST OKLAHOMA,

1972-73

Habitat Type and Plant Species	Summer 1972		Fall 1972		Winter 1972-73		Spring 1973	
Stabilized Dunes	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.
Acacia angustissima	3.3	25.8	8.0	11.3	3.8	9.8	2.0	10.0
Amaranthus retroflexus*	0.3	32.2	0.4	30.2	2.0	19.5	0	0
Ambrosia psilostachya*	3.5	61.3	6.8	66.0	13.6	58.5	4.6	70.0
A. trifida*	0	0	0.3	3.8	0	0	0	0
Andropogon sp.	0	0	0	0	0.2	7.3	0	0
Argemone intermedia	0	0	0.9	15.1	0.3	10.0	0	0
Asclepias sp.	0	0	0	0	<0.05	2.4	0	0
Bidens sp.	0	0	0	0	<0.05	2.4	0	0
Bromus sp.	50.3	67.7	12.5	54.7	0	0	0	0
Bumelia lanuginosa*	0	0	0.7	1.9	0	0	0	0
Carex spp.	4.5	35.5	1.4	11.3	2.7	36.6	2.2	30.0
Cassia fasciculata*	0	0	0	0	4.1	12.2	0	0
Celtis reticulata	6.0	16.0	2.2	7.5	12.0	14.6	1.8	15.0
Cenchrus pauciflorus	0	0	0	0	<0.05	2.4	0	0
Chenopodium spp.	1.6	67.7	1.8	37.7	1.8	51.2	9.4	75.0
Cirsium sp.	0	0	<0.05	1.9	0.1	4.9	0.1	5.0
Commelina erecta	3.5	22.6	2.8	30.2	1.4	19.5	1.4	15.0
Croton spp.	2.6	45.2	5.3	43.4	5.4	48.8	1.2	55.0

APPENDIX B (Continued)

Habitat Type and Plant Species	Summer 1972		Fall 1972		Winter 1972-73		Spring 1973	
	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.
Cyperus spp.	6.9	74.2	4.5	54.7	2.0	36.6	0.6	30.0
Desmanthus illinoensis	2.4	3.2	2.7	7.5	0.3	4.9	0	0
Desmodium sessilifolium	0	0	<0.05	1.9	0	0	0	0
Digitaria sanguinalis	0	0	1.5	11.3	0.1	10.0	0.1	5.0
Echinocloa crusgalli	0	0	0	0	<0.05	2.4	0	0
Eleocharis sp.	0	0	0	0	0	0	0.05	5.0
Erograstis sp.	0.2	6.6	<0.05	3.8	<0.05	2.4	3.2	15.0
Geranium carolinianum	<0.05	6.6	0.6	17.1	0.5	17.1	0.2	15.0
*Helianthus petiolaris**	<0.05	3.2	0	0	0.2	4.9	0.1	10.0
Heterotheca subaxillaris	<0.05	3.2	1.9	24.5	4.1	36.6	3.1	50.0
Indigofera leptosepala	1.0	3.2	3.9	5.7	1.5	2.4	0.2	5.0
*Iva ciliata**	0.3	12.9	8.7	9.4	3.8	12.2	1.5	10.0
Lepidium sp.	<0.05	3.2	0	0	0.1	2.4	0	0
Leptoloma cognotum	0	0	0	0	3.4	31.7	0.4	25.0
Lespedeza capitata	0	0	6.3	1.9	0	0	0	0
Lithospermum sp.	0.5	6.6	2.2	13.2	0.4	7.3	0	0
Melilotus alba	0.4	9.7	0.8	9.4	2.3	9.8	17.7	20.0
Panicum capillare & *dichotomiflorum**	0.2	38.7	2.4	47.2	1.5	34.1	4.6	30.0
*Panicum oligosanthes**	2.6	41.9	4.4	35.8	11.7	31.7	2.2	30.0
Panicum spp.	0	0	0	0	0.3	7.3	<0.05	5.0
*Paspalum setaceum**	1.8	32.3	3.9	56.6	8.0	48.8	0.2	20.0
Physalis sp.	0	0	0	0	2.7	31.7	0.6	35.0
Plantago aristata	0.1	3.2	<0.05	5.7	0.1	9.8	<0.05	5.0
Polygonum spp.	<0.05	3.2	0.1	1.9	<0.05	4.9	0.8	5.0
Prunus angustifolia	0	0	0	0	2.7	2.4	0	0

APPENDIX B (Continued)

Habitat Type and Plant Species	Summer 1972		Fall 1972		Winter 1972-73		Spring 1973	
	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.
Quercus marilandica	0	0	0.7	1.9	0	0	0	0
Rhus sp.	1.1	16.1	0.7	3.8	0.1	2.4	0.05	5.0
Rosa multiflora	0.4	6.5	0.1	5.7	0.5	9.8	0.2	5.0
Scirpus spp.	0.1	9.7	0.1	17.0	0.1	4.9	0	0
Setaria sp.	0	0	0.1	3.8	0.1	2.4	1.7	5.0
Sida sp.	0	0	0	0	0.05	2.4	0.1	15.0
Solanum sp.	0	0	0	0	0.1	12.2	0.1	20.0
Sorgum halepense	<0.05	3.2	0	0	0	0	0	0
Strophostyles spp.*	1.1	16.1	0.5	3.8	0	0	0	0
Symphoricarpus orbiculatus	<0.05	6.5	<0.05	1.9	<0.05	2.4	0	0
Teucrium canadense	3.8	29.0	8.0	35.8	13.3	31.7	38.8	55.0
Urtica sp.	0.1	6.5	0.3	9.4	0.2	12.2	0.1	25.0
Verbascum sp.	0	0	0	0	<0.05	4.9	0.8	10.0
Verbena bracteata	0.2	3.2	0.1	5.7	0.1	4.9	0	0
Vitis aestivalis	0	0	0	0	0.4	4.9	0	0
Unidentified	1.0	22.6	2.6	24.5	1.0	34.1	0.1	5.0
Cottonwood Bottomland								
Acacia angustissima	0.4	3.7	0	0	0	0	0	0
*Amaranthus retroflexus**	<0.05	7.4	0.2	25.0	<0.05	4.2	<0.05	20.0
*Ambrosia psilostachya**	3.8	59.3	7.5	75.0	5.4	62.5	7.3	80.0
Andropogon sp.	0	0	0	0	0.1	4.2	0	0
Argemone intermedia	<0.05	3.7	0	0	<0.05	4.2	0	0
Bromus sp.	1.6	18.5	0	0	0	0	0	0
Carex spp.	0	0	0.1	8.3	<0.05	8.3	0	0

APPENDIX B (Continued)

Habitat Type and Plant Species	Summer 1972		Fall 1972		Winter 1972-73		Spring 1973	
	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.
*Cassia fasciculata**	0	0	5.7	8.3	2.5	12.5	0	0
Celtis reticulata	0	0	0	0	0	0	0.5	20.0
Cenchrus pauciflorus	0	0	0	0	0.05	4.2	0	0
Chenopodium spp.	0.2	33.3	0.6	25.0	0.5	41.7	3.6	40.0
Cirsium sp.	0.1	3.7	0	0	0.05	4.2	0	0
Commelina erecta	0.3	3.7	0	0	0.1	4.2	0	0
Croton spp.	1.6	18.5	0.7	8.3	0.6	20.9	0	0
Cyperus spp.	0.2	22.2	0.1	16.7	0.2	12.5	0	0
Desmanthus illinoensis	0	0	2.1	16.7	0.2	8.3	0	0
Digitaria sanguinalis	0	0	0.4	8.3	0.2	12.5	0	0
Echinocloa crusgalli	0	0	0.1	8.3	0	0	0	0
Eleocharis sp.	0.9	3.7	0	0	0.7	8.3	2.6	20.0
Erograstis sp.	0.5	33.3	0.2	25.0	0.05	8.3	2.6	60.0
Geranium carolinianum	0.1	7.4	0	0	0.4	12.5	0.2	20.0
*Helianthus petiolaris**	0	0	0.1	8.3	0	0	0	0
Heterotheca subaxillaris	0	0	0	0	0.2	12.5	0	0
Indigofera leptosepala	1.7	3.7	0	0	0	0	0	0
*Iva ciliata**	0.2	11.1	0	0	0.2	12.5	0.6	40.0
Leptoloma cognatum	0	0	0	0	0.6	12.5	0	0
Melilotus alba	63.6	55.6	76.6	83.3	57.5	62.5	55.1	80.0
*Panicum capillare & dichotomiflorum**	0	0	0	0	0.5	12.5	0	0
*Panicum oligosanthes**	0.6	25.9	1.2	16.7	0.3	16.7	0	0
Panicum spp.	0.05	3.7	0	0	0	0	0	0
*Paspalum setaceum**	0.1	14.8	4.2	25.0	0.2	29.2	0	0
Physalis sp.	0	0	0	0	0.5	33.3	0.1	20.0

APPENDIX B (Continued)

Habitat Type and Plant Species	Summer 1972		Fall 1972		Winter 1972-73		Spring 1973	
	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.
Rhus sp.	0.3	3.7	0	0	1.8	4.2	0	0
Rosa multiflora	0.2	11.1	0	0	0.4	12.5	0	0
Scirpus sp.	0.5	18.5	1.6	58.3	1.2	25.0	0	0
Setaria sp.	0.3	33.3	<0.05	16.7	1.4	29.2	0	0
Solanum sp.	0.05	3.7	0	0	<0.05	12.5	0.2	60.0
Strophostyles spp.*	0.5	3.7	0	0	1.4	16.7	0	0
Teucrium canadense	20.1	48.1	4.8	33.3	25.0	62.5	27.2	60.0
*Triticum aestivum**	0.6	3.7	0	0	0	0	0	0
Urtica sp.	<0.05	3.7	0	0	0.1	16.7	0	0
Verbascum sp.	0	0	0	0	0.5	4.2	0	0
Verbena bracteata	0.6	11.1	0.05	8.3	0.1	8.3	0	0
Vitis aestivalis	0.5	11.1	0	0	0.2	4.2	0	0
Unidentified	0.4	18.5	1.3	8.3	0	0	0	0
Old Disced Strips								
Acacia angustissima	1.6	12.5	0	0	0	0	0	0
*Amaranthus retroflexus**	0.1	37.5	0.2	27.3	0	0	0	0
*Ambrosia psilostachya**	5.5	75.0	4.0	63.6	2.1	62.5	0.2	50.0
Argemone intermedia	0	0	0.1	9.1	0	0	0	0
Bromus sp.	47.2	75.0	2.7	9.1	0	0	0	0
Carex spp.	1.4	25.0	0	0	<0.05	12.5	0	0
*Cassia fasciculata**	0	0	0.3	9.1	1.6	12.5	0.3	25.0
Chenopodium spp.	0.2	50.0	0.4	45.5	10.9	87.5	14.3	100.0
Cirsium sp.	0	0	0	0	0.1	12.5	0.1	25.0
Commelina erecta	0.4	25.0	0	0	0	0	0	0

APPENDIX B (Continued)

Habitat Type and Plant Species	Summer 1972		Fall 1972		Winter 1972-73		Spring 1973	
	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.
Croton spp.	2.2	37.5	0.5	18.2	0.1	12.5	0	0
Cyperus spp.	6.2	50.0	<0.05	9.1	0.05	12.5	0.6	25.0
Desmanthus illinoensis	8.0	25.0	42.5	27.3	5.8	25.0	59.9	50.0
Digitaria sanguinalis	0	0	0	0	0.1	12.5	0	0
Echinocloa crusgalli	0	0	1.2	18.2	5.0	12.5	9.5	25.0
Eragrostis sp.	0.2	12.5	2.5	36.4	0.3	37.5	<0.05	25.0
Geranium carolinianum	0.5	37.5	0.4	27.3	0.4	12.5	0.5	50.0
Heterotheca subaxillaris	0	0	0.2	27.3	0.8	25.0	2.5	50.0
Indigofera leptosepala	0	0	0.2	9.1	0	0	0	0
Leptoloma cognatum	0	0	0	0	0.3	12.5	<0.05	25.0
Lithospermum sp.	0	0	0.1	9.1	0	0	0	0
Melilotus alba	0.8	25.0	11.1	36.4	11.1	62.5	0.2	25.0
Panicum capillare & *dichotomiflorum**	0.4	37.5	4.6	72.7	12.2	75.0	0.5	75.0
*Panicum oligosanthes**	4.9	37.5	0.4	36.4	0	0	0.4	25.0
*Paspalum setaceum**	0.5	37.5	1.0	27.3	<0.05	25.0	0.2	25.0
Physalis sp.	0	0	0	0	0.7	50.0	0.2	75.0
Polygonum spp.	0	0	0.1	9.1	0	0	0.5	50.0
Rhus sp.	0	0	0.2	9.1	0	0	0	0
Rosa multiflora	0.5	12.5	0	0	0	0	0	0
Scirpus spp.	0	0	0.4	36.4	0.1	12.5	0	0
Setaria sp.	<0.05	12.5	5.3	9.1	2.8	50.0	0.3	25.0
Solanum sp.	0	0	0	0	0.2	25.0	0.3	50.0
Sorgum halepense	0	0	0.2	9.1	0	0	0	0
Strophostyles spp.*	0	0	0	0	0	0	1.0	25.0
Teucrium canadense	18.7	62.5	27.3	63.6	43.4	75.0	6.7	75.0

APPENDIX B (Continued)

Habitat Type and Plant Species	Summer 1972		Fall 1972		Winter 1972-73		Spring 1973	
	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.
Urtica sp.	0	0	0.05	18.2	0	0	0.05	25.0
Verbena bracteata	0.5	12.5	0.1	9.1	0	0	0	0
Vicia spp.	0	0	0	0	0.2	12.5	0	0
Unidentified	0.2	25.0	0	0	0.05	12.5	0	0
Freshly Disced Areas								
Amaranthus retroflexus*	3.1	60.0	2.2	57.1	2.4	50.0	0	0
Ambrosia psilostachya*	10.8	40.0	0.9	14.3	4.7	50.0	2.9	100.0
Argemone intermedia	0	0	0	0	3.1	33.3	0	0
Carex spp.	0	0	0	0	4.6	66.7	0	0
Cassia fasciculata*	0	0	10.8	14.3	1.9	16.7	0	0
Chenopodium spp.	5.5	20.0	6.7	71.4	18.7	66.7	27.1	100.0
Cirsium sp.	0	0	0	0	0.4	16.7	0	0
Commelina erecta	0	0	0	0	4.5	16.7	0	0
Croton spp.	0	0	0.4	14.3	4.6	50.0	0	0
Cyperus spp.	2.0	20.0	1.5	42.9	9.3	66.7	0	0
Desmanthus illinoensis	0	0	2.2	14.3	0	0	0	0
Desmodium sessilifolium	0	0	0	0	3.8	16.7	0	0
Digitaria sanguinalis	0	0	1.1	14.3	0.1	16.7	0	0
Eragrostis sp.	0.1	20.0	0	0	0	0	1.6	100.0
Geranium carolinianum	0	0	6.8	14.3	0	0	0	0
Helianthus petiolaris*	0	0	0	0	0	0	4.8	100.0
Heterotheca subaxillaris	0	0	20.3	14.3	11.3	66.7	4.8	100.0
Indigofera leptosepala	0	0	0	0	1.6	16.7	0	0
Iva ciliata*	0	0	0.4	14.3	0.6	16.7	0	0
Melilotus alba	2.8	40.0	1.1	14.3	0	0	0	0

APPENDIX B (Continued)

Habitat Type and Plant Species	Summer 1972		Fall 1972		Winter 1972-73		Spring 1973	
	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.
Panicum capillare & dichotomiflorum*	2.0	20.0	0.2	14.3	7.6	83.3	36.7	100.0
Panicum oligosanthes*	0	0	0.3	14.3	1.6	16.7	0	0
Paspalum setaceum*	6.3	40.0	0.1	14.3	5.0	50.0	0.7	100.0
Physalis sp.	0	0	0	0	0.6	33.3	1.0	100.0
Setaria sp.	0	0	0	0	7.4	50.0	0	0
Strophostyles spp.*	26.9	40.0	13.2	28.6	0	0	0	0
Teucrium canadense	0	0	1.0	14.3	6.1	33.3	20.1	100.0
Verbena bracteata	0	0	0	0	0.2	16.7	0	0
Vicia spp.	36.9	20.0	10.6	42.9	0	0	0	0
Unidentified	1.9	20.0	0	0	1.1	16.7	0	0
Mature Food Plots								
Amaranthus retroflexus*	0.4	42.9	1.8	75.0	17.6	60.0	no data	
Ambrosia psilostachya*	1.2	42.9	0	0	8.7	40.0		
Bromus sp.	34.0	57.1	4.8	25.0	0	0		
Carex spp.	0	0	0	0	1.5	20.0		
Chenopodium spp.	0.3	28.6	0	0	4.2	60.0		
Croton spp.	2.9	42.9	0.5	25.0	0	0		
Cyperus spp.	0.4	57.1	0.1	50.0	0	0		
Desmanthus illinoensis	0	0	0	0	19.0	20.0		
Eragrostis sp.	0	0	0.2	25.0	1.2	60.0		
Geranium carolinianum	0.1	14.3	0.1	25.0	0	0		
Heterotheca subaxillaris	0	0	0.05	25.0	0	0		
Iva ciliata*	0.9	14.3	0	0	0	0		

APPENDIX B (Continued)

Habitat Type and Plant Species	Summer 1972		Fall 1972		Winter 1972-73		Spring 1973	
	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.
Leptoloma cognatum	0	0	0	0	0.4	20.0	no data	
Lithospermum sp.	1.6	14.3	0	0	0	0		
Melilotus alba	0.1	14.3	0	0	6.1	80.0		
Panicum capillare & *dichotomiflorum**	1.3	71.5	34.4	75.0	1.7	60.0		
*Panicum oligosanthes**	0.3	42.9	0.3	25.0	0.6	20.0		
*Paspalum setaceum**	1.9	57.1	<0.05	25.0	0	0		
Plantago aristata	0	0	0	0	0.3	20.0		
Rhus sp.	0	0	0.6	25.0	0	0		
Scirpus spp.	0	0	0	0	12.4	80.0		
Setaria sp.	0.6	28.6	6.5	75.0	0	0		
Solanum sp.	0.1	14.3	0	0	1.3	40.0		
Sorgum halepense	0	0	0.3	25.0	0	0		
*Sorgum vulgare**	0	0	38.7	25.0	1.8	20.0		
Strophostyles spp.*	0	0	0.5	25.0	12.1	40.0		
Teucrium canadense	0.3	42.9	0.3	25.0	11.5	40.0		
*Triticum aestivum**	53.3	100.0	10.5	75.0	0	0		
Urtica sp.	0.1	14.3	0	0	0	0		
Verbena bracteata	0	0	<0.05	25.0	0.5	20.0		
Unidentified	<0.05	14.3	0	0	0	0		
Upland Woods								
*Ambrosia psilostachya**	0	0	1.6	66.7	0.4	33.3	no data	
Bromus sp.	17.2	100.0	0.2	33.3	0	0		
Carex spp.	0	0	0	0	0.1	16.7		

APPENDIX B (Continued)

Habitat Type and Plant Species	Summer 1972		Fall 1972		Winter 1972-73		Spring 1973	
	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.
Celtis reticulata	0	0	4.5	33.3	64.1	50.0	no data	
Chenopodium spp.	0.1	50.0	1.1	66.7	0.3	50.0		
Commelina erecta	0	0	0	0	0.4	16.7		
Croton spp.	0	0	6.3	33.3	1.5	50.0		
Cynoglossum sp.	0	0	5.3	33.3	0	0		
Geranium carolinianum	0	0	2.2	66.7	0.3	33.3		
*Iva cilata**	2.5	50.0	5.8	66.7	0.1	16.7		
Lithospermum sp.	0	0	0	0	0.8	33.3		
Melilotus alba	0	0	0	0	0.2	33.3		
*Panicum oligosanthes**	0	0	0.3	33.3	0.5	33.3		
*Paspalum setaceum**	0	0	0	0	<0.05	16.7		
Physalis sp.	0	0	0	0	<0.05	33.3		
Prunus angustifolia	0	0	12.0	33.3	0	0		
Quercus marilandica	0	0	41.3	33.3	12.5	16.7		
Rhus sp.	45.7	100.0	1.6	66.7	8.3	33.3		
Rosa multiflora	0	0	0.9	33.3	1.2	33.3		
Setaria sp.	0.1	50.0	0	0	<0.05	16.7		
Strophostyles spp.*	5.3	50.0	0	0	0	0		
Symphoricarpus orbiculatus	3.4	50.0	0	0	0.1	16.7		
Teucrium canadense	0	0	0	0	0.1	16.7		
Tragopogon sp.	15.6	100.0	0	0	6.1	16.7		
Verbascum sp.	10.0	50.0	0	0	0	0		
Vitis aestivalis	0	0	18.5	33.3	1.1	33.3		
Unidentified	0	0	3.1	66.7	0	0		

*Indicates species important as quail food

APPENDIX C

PERCENT WEIGHT AND PERCENT OCCURRENCE

OF ARTHROPODS IN SWEEP NET SAMPLES,

CANTON PUBLIC HUNTING AREA,

NORTHWEST OKLAHOMA,

1972-73

Habitat Type And Taxonomic Group	Summer 1972		Fall 1972		Winter 1972-73	
Stabilized Dunes	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.
Arachnida	4.7	83.3	12.3	70.8	0	0
Hymenoptera	2.0	53.3	3.9	41.7	0	0
Diptera	3.2	80.0	4.7	56.3	77.0	14.3
Homoptera	2.3	80.0	3.1	66.7	23.0	7.1
Hemiptera	8.6	63.3	60.0	91.7	0	0
Coleoptera	21.7	90.0	11.7	58.3	0	0
Orthoptera	57.5	80.0	3.9	18.8	0	0
Cottonwood Bottomland						
Arachnida	7.5	74.1	9.9	60.0	0	0
Hymenoptera	5.6	85.2	2.2	30.0	9.8	14.3
Diptera	5.3	74.1	12.8	90.0	53.7	28.6
Homoptera	4.2	77.8	16.4	90.0	36.6	14.3

APPENDIX C (Continued

Habitat Type And Taxonomic Group	Summer 1972		Fall 1972		Winter 1972-73	
	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.
Hemiptera	10.6	48.1	46.4	80.0	0	0
Coleoptera	38.1	66.7	12.3	70.0	0	0
Orthoptera	28.8	37.0	0	0	0	0
Old Disced Areas						
Arachnida	4.9	100.0	5.3	70.0	0	0
Hymenoptera	0.8	71.4	7.0	20.0	42.9	33.3
Diptera	2.0	100.0	6.6	80.0	0	0
Homoptera	1.9	100.0	2.9	70.0	57.1	33.3
Hemiptera	4.1	85.7	58.9	100.0	0	0
Coleoptera	14.7	85.7	16.4	70.0	0	0
Orthoptera	71.7	85.7	2.8	10.0	0	0
Freshly Disced Areas						
Arachnida	1.0	20.0	0.9	66.7	0	0
Hymenoptera	2.3	40.0	0	0	0	0
Diptera	30.5	80.0	0.5	33.3	0	0
Homoptera	9.0	80.0	3.1	100.0	0	0
Hemiptera	10.9	40.0	77.2	66.7	0	0
Coleoptera	43.4	80.0	4.2	33.3	0	0
Orthoptera	2.8	20.0	13.8	33.3	0	0

APPENDIX C (Continued)

Habitat Type And Taxonomic Group	Summer 1972		Fall 1972		Winter 1972-73	
Mature Food Plots	% Wt.	% Occ.	% Wt.	% Occ.	% Wt.	% Occ.
Arachnida	9.5	50.0	6.3	66.7	0	0
Hymenoptera	0.5	50.0	0	0	0	0
Diptera	0.8	75.0	0.9	33.3	0	0
Homoptera	3.1	75.0	5.1	33.3	0	0
Hemiptera	0.4	25.0	62.9	66.7	0	0
Coleoptera	11.6	50.0	6.7	66.7	0	0
Orthoptera	74.1	50.0	18.1	33.3	0	0
Upland Woods						
Arachnida	46.5	100.0	25.1	100.0	0	0
Hymenoptera	2.3	100.0	0.5	33.3	0	0
Diptera	3.5	100.0	7.1	66.7	0	0
Homoptera	1.5	50.0	0.6	33.3	0	0
Hemiptera	22.4	100.0	31.5	33.3	0	0
Coleoptera	21.5	100.0	35.2	100.0	0	0
Orthoptera	1.8	50.0	0	0	0	0

VITA

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